Re: slides for next week

Jim Lazorchak to: Naddy, Rami 02/03/2012 03:59 PM
Cc: Gail Franklin, Kristen Keteles

From: Jim Lazorchak/CI/USEPA/US
To: "Naddy, Rami" <Rami.Naddy@aecom.com>,
Cc: Gail Franklin/R8/USEPA/US@EPA, Kristen Keteles/R8/USEPA/US@EPA

Naddy

Here is the current version of the presentation I will be making on our comparative salt and other reference toxicant sensitivity studies. I want to make sure that you realize that if there are mayflies that are related to the species we have in a watershed where you have discharges from Oil and Gas facilities then Ceriodaphnia may not be protective enough. Also the chemistry you sent me seems to indicate a high CO3 dominated system with high chloride as well. So the analyses EPA has done with coal mine waste from valley fills in KY and WVa indicate mayflies are also sensitive to elevated levels of carbonate or bicarbonate.

Region 8 Mayfly Presentation v3.pptx

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"Naddy, Rami" Kristen, 02/03/2012 05:09:35 PM

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Date: 02/03/2012 05:09 PM
Subject: slides for next week

Kristen,

I'm a little delayed in getting you the slides I am pulling together for next week's meeting. Should have them to you Monday afternoon. Sorry for the delay (enjoying our snow storm). -Rami

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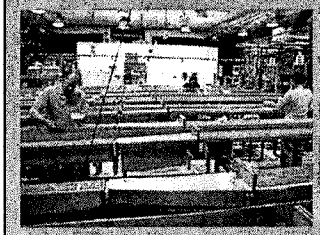
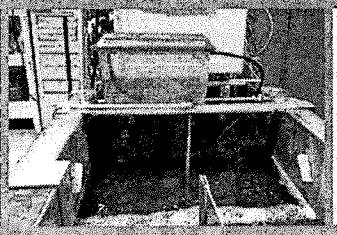
Studying the Effects of Excess TDS on Stream Biota – Field relevance – benchtop - mesocosm tests (2011) Preliminary Results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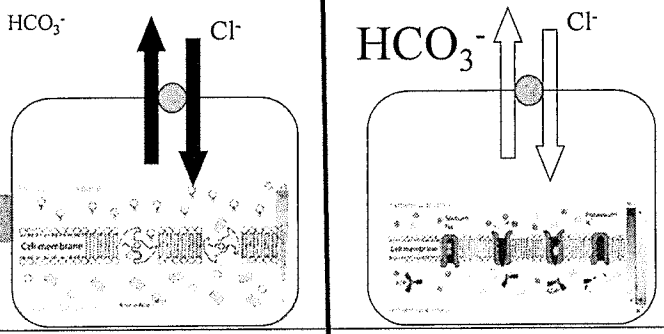
What's the potential problem with TDS?

-Regulation of Ionic Balance

Stream



Inside animal

HCO_3^- formed during metabolism.

$HCO3^-$ Flows down concentration gradient in exchange for Cl^-

Cl^-

Cl^-

HCO_3^- cannot flow passively down concentration gradient.

2

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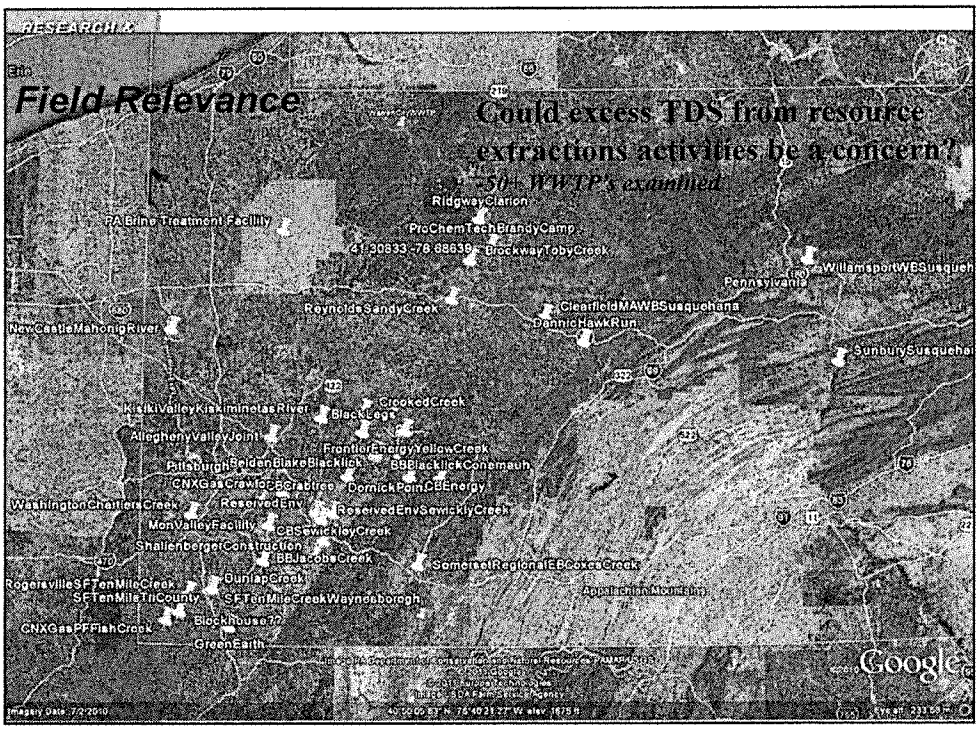
Potential Effects Chain

Stressor	Stream Interface Effect— Physical	Tissue level Effect— Physiological mechanism	Organism level Effect— Population mechanism	Population level Effect— Extirpation mechanism	System-Level Effect
Salt concentration Ionic Composition	Ion Exchange Osmotic stress Competition for exchange	Internal ionic gradients Internal pH Bioavailability of essential elements Volume control Toxicity to specific ions	Migration Growth Reproduction Death Metabolism Behavior Development	Decline in occurrence and extirpation of benthic invertebrate genera Decline in occurrence and extirpation of fish species Decline in other species	Change food web structure Change retention and storage Effect natural attenuation



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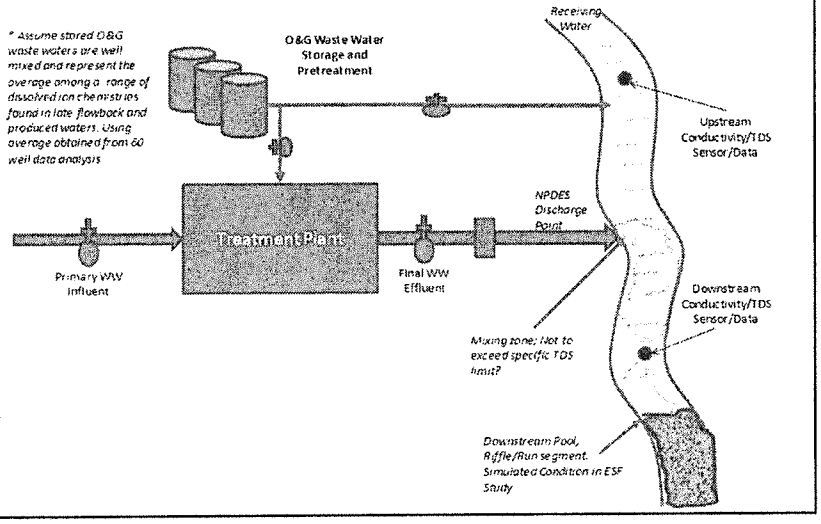
Generalized Risk Scenario for Simulation

Conceptual Diagram of Simulation Scenario Targeted for ESF TDS Study: Effects of produced water from resource extraction activities discharged to natural waters.



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WWTP Accepting or Proposed Oil and Gas WasteWater from Resource Extraction Operations

- *-Used USGS's "streamstats" to estimate flow conditions in receiving streams.*
- *-Coupled with Design flows and TDS concentrations in late flowback and produced waters, in-stream, mixing zone conditions were estimated.*
- *-High potentials for Excess TDS in ca. 50% of cases*
- *-This analysis was also used to set environmentally relevant experimental TDS doses*

Type	#	Drainage Area Above Point Source (mi2)	[TDS] Mixing Zone (LF2yr)	[TDS] Mixing Zone (LF10yr)	[TDS] Mixing Zone (BF10yr)	Potential Problems (50%)
Treating or Proposed to Treat Marcellus O&G WW (as of ~2010)	12	5194	175	175	175	
	16	6134	175	175	175	
	17	5213	175	175	175	
	14	133	179	182	175	
	18	11582	180	184	176	
	13	42	186	192	177	
	47	18441	182	186	177	
	11	5413	213	239	181	
	48	601	215	240	183	
	46	5687	215	244	184	
	44	5977	224	251	185	
	6	8220	252	308	197	
	39	310	286	350	197	
	37	1549	282	344	199	
	43	3139	301	380	201	
	2	4531	392	557	208	
	41	114	383	556	216	
	19	702	334	417	217	
	40	99	442	619	232	
	16	139	1530	2554	373	1
	3	191	1282	2075	392	2
	8	1355	1581	3235	452	3
	5	1360	1482	2271	454	4
	10	51	892	1093	481	5
	42	1113	1526	2268	546	6
	7	280	5568	11090	721	7
	38	37	1727	1823	1074	8
	4	14	7883	15783	1444	9
	20	191	6455	15302	1486	10
	35	45	21371	43799	2511	11
	50	45	18082	27200	3274	12
	22	9	3847	3982	4722	13
	21	60	47527	79174	7272	14
	45	13	47920	98014	8707	15
	1	4	87719	121564	13356	assertion pond
	9	11	117731	149178	40719	will treat ARD
	49	3	110914	142575	44529	reuse/recycle
Treating Coal Bed Methane WW	30	1737	276	371	194	
	29	1724	277	373	194	
	25	758	618	902	276	1
	33	1310	981	1450	548	2
	27	280	2116	3809	493	3
	32	398	2452	3954	807	4
	23	410	2953	4779	701	5
	24	8	8270	21534	716	6
	28	14	7840	17342	1269	7
	26	2	37705	82868	2831	8
	31	29	32882	64224	4264	9
	36	51	41259	75879	5815	10
	34	18	31724	59828	7160	11

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Determine the composition of the Excess TDS from existing well data; *ca. 60 well chemistry data used, majority published.*

Dissolved Solid	Atomic Mass	~60 wells; Late Flowback and Producing Average (mg/L)
Chloride	35.45	97599
Sodium	22.99	34810
Calcium	40.08	12630
Strontium	87.62	1828
Barium	137.3	1573
Magnesium	24.31	1200
Bromide	79.9	761
Total Dissolved Solids		170029

**Configured Excess TDS Doses for WET and Mesocosm Tests from top three ions, comprising 95% of TDS; from well data*

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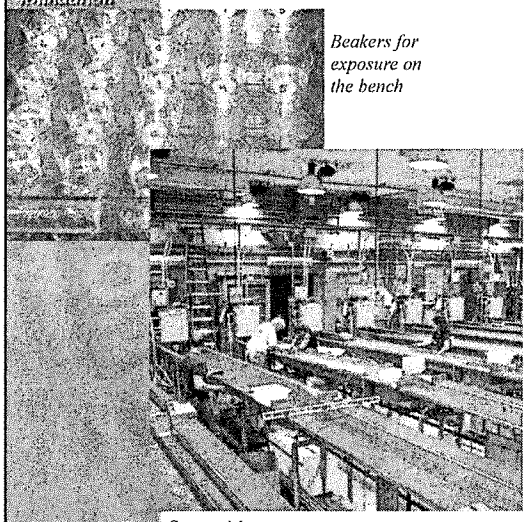
Use a coupled Bench-Top/Mesocosm Approach –



Beakers for exposure on the bench

Stream Mesocosms

1. Run single organism tests in WET framework
2. Simulate ecoStructure-Function to understand the role and response of small streams to changing nature of Point Sources.
3. Study abiotic/biotic interactions as determinants of the role of small stream ecosystems in sustainable water management

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Parameters measured during ESF Excess TDS Study

Matrix	Parameter
Mesocosm Continuous Monitoring	Indoor ESF Irradiance
	Water Temp
	SpCond
	pH
	ORP
	DO
	Turbidity
	Bivalve (Rainbow Mussel) Gape
Mesocosm Surface Water Grab Sampling	RP (Uptake)
	NH4 (Uptake)
	NO2-3 (Uptake)
	TP (Uptake)
	TN (Uptake)
	CHLa
	TOC
	Alkalinity/Hardness
	Anions-Cations - Metals
	TDS
ESF-Tile Section (BP) Sampling	Chl-a
	AFDM
	Algal ID
	Bacterial Counts
Mesocosm Gravel Section Biotic (BP, BO) Sampling and Drift (DO) Sampling	Chl-a
	AFDM
	Algal ID
	Periphyton CNP
	Bacterial Counts
	Drift
	MacroINV Count
	MacroINV ID
	MacroINV Biomass
Interstitial Water (IG) Sampling	RP
	NH4
	NO2-3
	TP
	TN
	TOC

Matrix	Parameter
Gravel Specific Sediment Sampling	Tsed Accum
	gt2mm SedM
	.250_2mm SedM
	1.2_250um SedM
	gt2mm LOI
	.250_2mm LOI(CPOM)
	1.2_250um LOI(FPOM)
	.250_2mm (CPOM) CNP
	1.2_250um (FPOM) CNP
Litter Decomposition	Ash Corrected Weight Loss
	C,N,P content trend
Toxicological Assay	7 d Larval Fish Growth - (WET Approach)
	7 d Larval Fish Mortality (WET Approach)
	Juvenile Mussel (GreenFloater) Mortality/Growth
	Mayfly Growth (SideStreamEnclosure)
	Mayfly Mortality (SideStreamEnclosure)
	Mayfly Growth (in situ)
	Mayfly Mortality (In-situ)
	BenchTop Acute Testing of Mesocosm Doses
Boundary Conditions	Atrazine-ELISA
	RP
	NH4
	NO2-3
	UREA
	TP
	TN
	Turbidity
	Rainfall
	Inflow
	Recirculation Flow
	UF/RO Flow
	UF/RO Conductance
	RTD (hydraulics)
	Gas Tracer - Reaeration
	Incident Irradiance Mesocosm Profile
	Near-Bed Velocity

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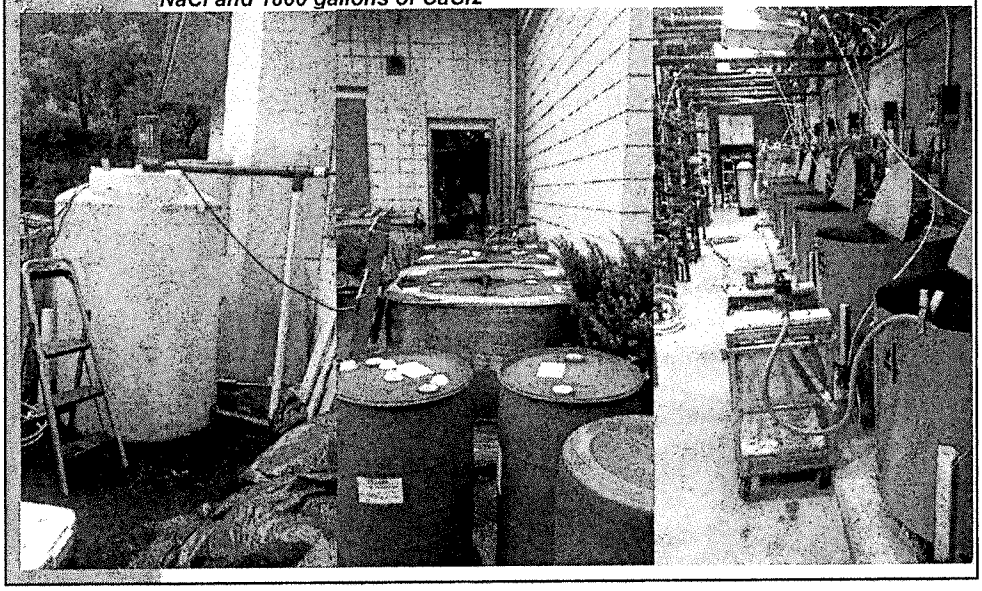
NaCl mixing Tank, CaCl2 drums, and ESF ChemFeedTanks - 17000 lbs of NaCl and 1800 gallons of CaCl2



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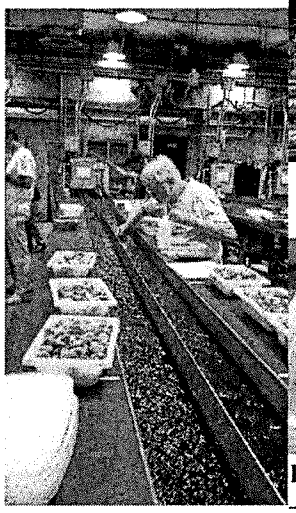
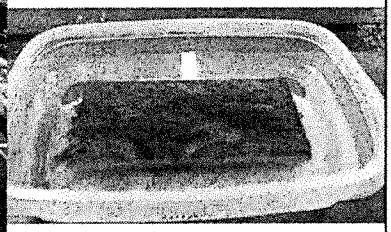
Gravel and Tile Section Sampling – Weekly to Biweekly



Macroinverts – identified, counted and measured



Periphyton Bacteria, Algae, etc – identified and/or measured

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Leaf Litter Bag Sampling and Processing for Decomposition; Macroinvert Sorting/Id'ing

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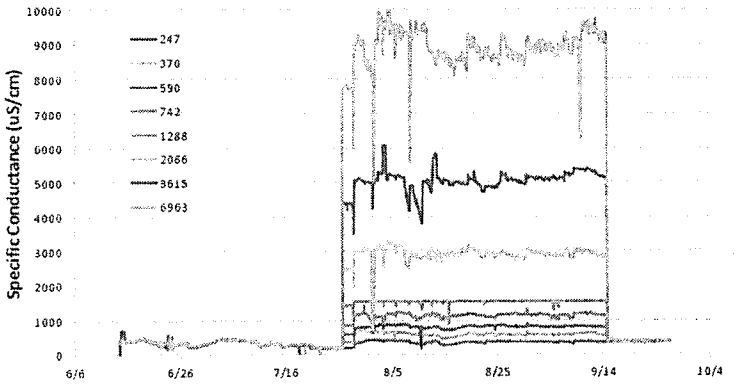
TDS dosing reflected in water Specific Conductance, a sensor resides in the tail tank of each mesocosm



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The Realized Excess TDS – that measured in the mesocosms

	PreDosing			Dosing						PostDose	
Date:	19-Jul	26-Jul	28-Jul	2-Aug	9-Aug	23-Aug	6-Sep	Dosing Period Average	Target	20-Sep	4-Oct
Sample ID	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L			mg/L	mg/L
E01	226	137	182	304	266	247	236	247	240	266	
E04	178	198	262	440	413	392	343	370	361	207	
E05	263	205	420	652	NA	586	703	590	501	242	
E06	268	224	631	796	732	774	778	742	695	302	
E03	254	218	1025	1363	1337	1322	1394	1288	1062	262	
E07	277	367	1883	2273	2181	2389	1602	2066	1812	222	
E02	272	195	3100	3810	3354	3595	4214	3615	3173	480	
E08	295	65	5714	7382	7252	7130	7337	6963	5655	229	
QC_200	284		300			286	235			173	
QC_6000	5767		5753			5861	5906			5893	
QC_Blank	16		75			53	2			2	

Excess TDS was:

63% Chloride

24% Sodium

9% Calcium

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Preliminary and Largely Qualitative Statements

1 month colonization
42 days dosing of Excess TDS
3 week recovery (just ended)

Bulk response of mesocosm biotic structure was observed in the two highest TDS doses (3615 and 6963 {ave TDS over dosing period} – periphyton effects observed at 742 TDS.
-Juvenile mussel mortality and growth
-Long strands of colonial diatoms and a filamentous red macroalgae replaced other interspersed diatoms and bluegreen mats.
-Polycentropid caddisfly cases were absent or nearly so.

**Quantitative analysis centered on using regression approach to estimate the NEC for all meso-scale endpoint should be available by the end of the year.*

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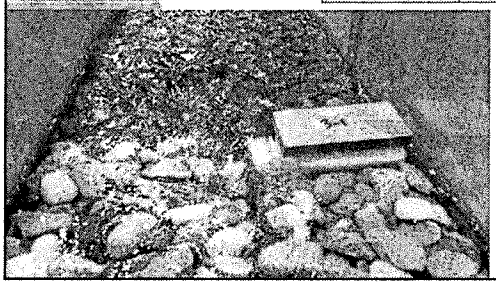
Juvenile Mussels

Treatment	Date:	28-Jul	Date:	12-Aug	Date:	16-Aug	Date:	26-Aug	Mortality	Date:	3-Aug	Mortality	Date:	23-Aug	Mortality	Date:	13-Sep	Mortality	Measured	Nominal
	Initials:	RK/PW/DM	Initials:	RK/DM	Initials:	RK	Initials:	RK/PW/DM	since	Initials:	PW/DM	since	Initials:	PW/DM	since	Initials:	PW/DM	since	Ave TDS	Specific
	Recovered	Live	Recovered	Live	Recovered	Live	Recovered	Live	7/15/11	Recovered	Live	7/29/11	Recovered	Live	8/5/11	Recovered	Live	8/23/11	Dose mg/L	Conductance
1	NA	9	8	8	*	8	8	8	0	8	8	0	8	8	0	8	8	0	247	356
2	NA	9	6	6	*	6	6	6	0	7	7	0	7	6	1	6	4	2	742	1069
3	NA	9	5	4	*	5	7	6	1	6	6	0	6	6	0	6	6	0	3615	3663
4	NA	9	6	9	*	9	8	8	0	6	6	0	6	6	0	6	6	0	3615	5663
5	NA	9	9	9	*	9	10	10	0	10	8	2	8	8	0	7	7	0	1285	2063
6	NA	9	8	7	*	8	8	8	0	8	8	0	7	8	2	8	8	0	1285	2063
7	NA	9	9	8	*	8	8	7	1	7	7	0	7	7	0	7	7	0	372	578
8	NA	9	8	8	*	8	7	5	2	5	5	0	5	5	0	5	5	0	372	578
9	NA	9	9	8	*	8	8	8	0	8	7	1	7	7	0	7	7	0	930	1420
10	NA	9	7	7	*	8	7	7	0	7	7	0	7	7	0	7	4	3	930	1420
11	NA	9	9	7	*	8	8	8	0	7	6	1	6	6	0	6	6	0	742	1159
12	NA	9	7	7	*	8	8	6	2	6	6	0	6	6	0	6	5	1	742	1159
13	NA	9	8	6	*	8	7	7	0	6	6	0	6	6	0	6	6	0	2066	3226
14	NA	9	8	7	*	8	8	8	0	8	6	2	6	4	2	4	4	0	2066	3226
15	NA	9	8	7	*	9	8	8	0	6	6	0	6	6	0	6	6	0	6963	10880
16	NA	9	8	8	*	8	7	7	0	7	0	7	0	0	0	0	0	0	6963	10880
							Total mortality		6	Total mortality		39	Total mortality		5	Total mortality		3		



**Juvenile enclosure positioned in-situ in gravel section*

100% mortality in two highest doses after two wks

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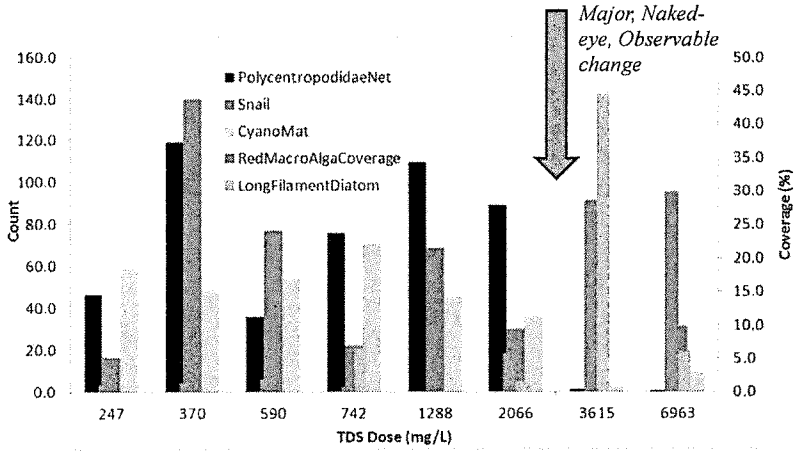
Results, Qualitative Biotic Surveying: End of dosing period



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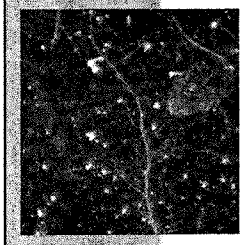
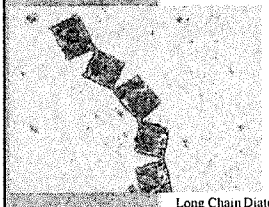
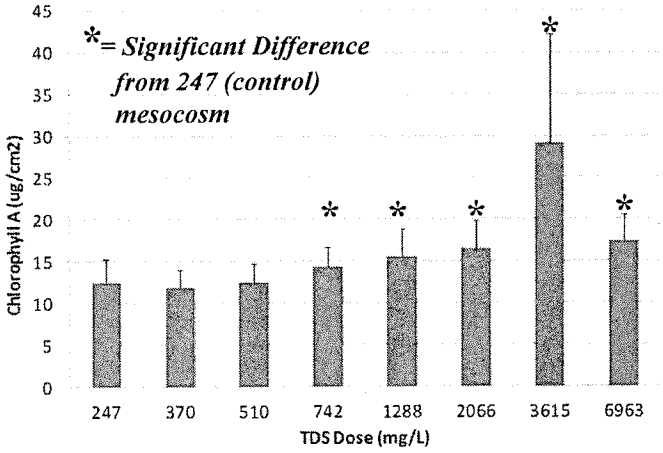
Periphyton Chlorophyll A: Averaged over Dosing Period

Red macro algae = *Compsopogon*

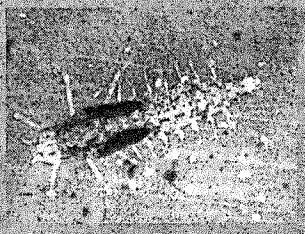
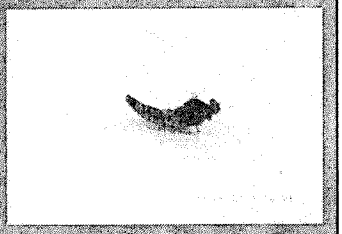




Long Chain Diatom= *Pleurosira*



Bench Scale and Ex-SituTests Using ESF TDS Water Samples Using CENTROPTILUM TRIANGULIFER and other standard organisms (EPHEMEROPTERA: BAETIDAE)

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Background

- Organism chosen for this study was *Centroptilum* ***triangulifer*** **an obligate parthenogenetic mayfly** that inhabits slow flow or depositional areas in streams throughout the northeastern United States and eastern Canada (Sweeney and Vannote, 1984).
- Their **life cycle is ~30 days at 25^0 C** from newly hatched larvae to emergent adult. They lay **1000+ eggs per female** and larvae normally **feed on periphytic algae and diatoms**.
- Previous studies have utilized mayflies in toxicity studies, and results indicate the organism may be very sensitive to certain toxicants. (Xie, Funk, Buchwalter 2009) (Conley, Funk, Buchwalter 2009) (Hassell, Kefford, Nugegoda 2006) (Standley, Sweeney, Funk 1994) (Sweeney, Funk, Standley 1992)

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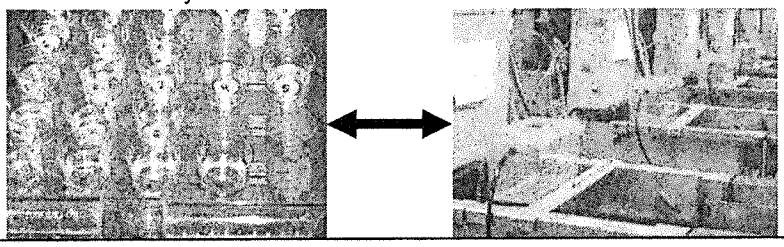
Toxicity Tests

- Based on EPA's Acute and Chronic Whole Effluent Toxicity Manual.
- Acute tests were run simultaneously with three species. *C. triangulifer*, *Ceriodaphnia dubia*, and *Daphnia magna*
- Moderately Hard Reconstituted Water (EPA Acute Manual 2002) was used as control and dilution water.
- Chronic Tests were run on the bench top and ex-situ; 7, 14, or 20 day
- Conductivity, pH, dissolved oxygen, and temperature were recorded daily for concentrations and renewal solution.



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Acute Tests Results on Early Test TDS Samples in Distilled Water and East Fork River Water

NaCl/CaCl in DI

Conc.	TDS mg/L
MHRW	nd
#1	nd
#2	242
#3	383
#4	571
#5	946
#6	1696
#7	3009
#8	5540

C. triangulifer

LC50	2720.24
95% UC	3173.55
95% LC	2331.68
NOEC	1696

C. dubia

LC50	3418.64
95% UC	3859.5
95% LC	3028.14
NOEC	1696

D magna

LC50	NA
NOEC	NA

NaCl/CaCl in EFR

Conc.	TDS mg/L
MHRW	nd
#1	nd
#2	242
#3	383
#4	571
#5	946
#6	1696
#7	3009
#8	5540

LC50	3754
95% UC	5364
95% LC	2626
NOEC	1696

LC50	3222
95% UC	3668
95% LC	2830
NOEC	1696

LC50	NA
NOEC	NA

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Conditions for Acute Testing All 3 Species

Acute Test Conditions	
Age of Organisms	< 24 hrs
Test Duration	48 hours
Test Temp	25° C +/- 1°C
Light Cycle	16 light/ 8 dark
Feeding	**0.1 ml diatom mix/15 ml**
Water Renewal	Daily
Endpoint	Mortality
Test Criteria	<90% survival in control

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Chronic Test Conditions

Duration of test, food, volume of solution and endpoint varied with each species as listed below:

C. triangulifer

14 days duration

Food: 0.2 ml daily 10 days, 0.4 ml daily for remaining 4 days
Volume: 15ml
Temperature: 25°C

Endpoint: Growth as measure by head capsule width, length, and weight

Test Criteria: >90% survival in controls

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Chronic Test Conditions

C. dubia (based on conditions listed in EPA chronic manual)

7 days duration

Food: 0.2 ml *Selenastrum* and 0.1 ml FFAY daily
Volume: 15ml
Temperature: 25°C

Endpoint: # of young reproduced
Test Criteria: Avg. 15 young/female in 3 broods
>80% survival in control

Larval Fathead Minnow 7-day Survival/ Growth
(Modified conditions EPA chronic manual & Continuous Ex Situ Exposures)

7 days duration

Food: 0.1 ml Brine Shrimp daily/Replicate (0.3/Gallon Tank Flow Thru)
Volume: 200ml/Replicate
Temperature: 25°C (Temperature 20-22)

Endpoint: Growth as weight
Test Criteria: > 250 ug Mean dry weight Controls,
>80% survival in the control

Raw data

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Chronic Tests Results on Samples Collected From ESF in a WET Format (3 samples collected over 7-days)

** Note, referenced constituent effect concentrations not normalized to average measured TDS, conductance, or specific ions (all nominal) at this point.*

C. triangulifer
14-day Growth Wt

Cond	IC25	977.038
	95% UC	1018.636
	95% LC	627.104
	NOEC	888
	LOEC	1268

C. dubia
7-day Fecundity

Test 1

Cond	IC25	3037.438
	95% UC	3569.509
	95% LC	895.077
	NOEC	3313
	LOEC	5116

Test 2

Cond	IC25	3895.922
	95% UC	4204.643
	95% LC	3432.734
	NOEC	3297
	LOEC	5614

Ex Situ ESF Continuous Flow Test – 20day Duration – Survival Results

Concentration (uS/CM)	Number exposed	Mortalities
Stream 1 (Ave= 359.21 uS/CM)	60	4*
Stream 4- (567.05 uS/CM)	60	0
Stream 5- (807.05 uS/CM)	60	0
Stream 6- (1133.55 uS/CM)	60	0
Stream 3 - (1512.09 uS/CM)	60	3
Stream 7- (2910.42 uS/CM)	60	40
Stream 2 - (4937.46 uS/CM)	60	57
Stream 8 - (8884.52 uS/CM)	60	60

LC50	2614
95% UC	2410
95% LC	2835
NOEC	1512

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Chronic Tests Results 7-day Larval Fathead Minnow From ESF

WET Test

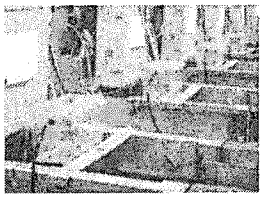
Cond	IC25	3727.55
	95% UC	4002.48
	95% LC	3327.72
	NOEC	3313
	LOEC	3313-5116

Ca	IC25	195.73
	95% UC	221.32
	95% LC	168.78
	NOEC	164
	LOEC	164-302

Na	IC25	522.15
	95% UC	582.55
	95% LC	444.66
	NOEC	438
	LOEC^	438-804

Ex Situ ESF Continuous Flow Test

Cond	IC25	**4036.84**
	95% UC	8076.43
	95% LC	3350.58
	NOEC	5380
	LOEC	8800



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Summary of Chronic Results

C. Triangulifer 14-day Growth Wt (AWBERC)

Cond	IC25	977.038
	95% UC	1018.636
	95% LC	627.104
	NOEC	888
	LOEC	1268

Na	IC25	83.184
	95% UC	88.366
	95% LC	28.876
	NOEC	71
	LOEC	123

C. dubia 7-day Fecundity

Cond	IC25	3037.438
	95% UC	3569.509
	95% LC	895.077
	NOEC	3313
	LOEC	5116

Na	IC25	421.483
	95% UC	506.469
	95% LC	65.682
	NOEC	438
	LOEC	804

Fathead 7-day Growth

Cond	IC25	**4036.84**
	95% UC	8076.43
	95% LC	3350.58
	NOEC	5380
	LOEC	8800

ESF 7-day Growth

Na	IC25	30.6
	95% UC	1562.45
	95% LC	19.82
	NOEC	228
	LOEC	438

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Conclusions For Bench-Tests

- Mayfly overall more sensitive to TDS than Ceriodaphnia.
- Larval Fathead results indicate larval fish may be as sensitive or close to Mayfly sensitivity.
- Organic Material and/or Suspended Solids may reduce toxicity of salts.

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Preliminary TDS Gradient Effects

247-370-590-742-1288-2066-3615-6963

Potential for periphytic structure change

Mayfly Growth

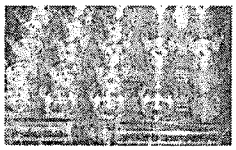
Mayfly Mortality

Mussel Mortality, Caddisfly Extripation, Algae shifts

Larval Fish

FIELD

MESOCOSM



LAB

Increasing Ecological Relevance

Increasing variability/decreasing level of control